DIRECTIONS

177708 Issue 2

8926 and 8927 GENERAL PURPOSE PLATINUM

RESISTANCE THERMOMETER ASSEMBLIES

LEEDS & NORTHRUP

MP MASTER
MA23310

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Temperature Range: -200 to +500°C[1]

Resistance at 0°C: 100 ±0.1 ohm.

Resistance Temperature Relationship: Thermometers obey equations 9 and 10 (a) of the International Practical Temperature Scale of 1968 (IPTS-68) where

$(\alpha) = 0.003916 \pm 0.000008$

$(\delta) = 1.51 \pm 0.02$

in the range 0°C to 500°C. In the range 0°C to -200°C a term of the form $\beta \left(\frac{t}{100} - 1\right) \left(\frac{t}{100}\right)^3$ is added where typically $\beta = 0.090$.

Excitation Current: 1 mA recommended, maximum 5 mA.

Sensitive Portion: 25 mm section from tip.

Typical Conformity [2]:

Temp °C	Tolerances ±ohms	±°C
-200	0.12	0.30
-150	0.13	0.31
-100	0.10	0.24
- 50	0.10	0.24
0	0.10	0.24
50	0.14	0.35
100	0.20	0.50
150	0.25	0.65
200	0.30	0.80
250	0.35	0.95
300	0.40	1.10
350	0.45	1.25
400	0.49	1.40
450	0.55	1.60
500	0.61	1.80

Stability: In the range 0 to 100°C, typically better than 0.004 ohm (0.010°C) per year when referenced to the ice-point (0°C).

Repeatability: Typically better than 0.02 ohm (0.050°C) over full temperature range; 0.002 ohm (0.005°C) in range 0 to 100°C.

Insulation Resistance: 100 megohms at 20°C, one megohm at 500°C.

Recommended Maximum Immersion: 230 mm (9.0") for temperatures below 75°C. 180 mm (7.0") for temperatures above 75°C.

Minimum Immersion [3]:	75 mm (3")
Construction:	High purity Al_2O_3 internal insulation in sealed assembly; temperature resisting head, two metres of multi-core shielded cable and 5-pin DIN type plug (-A Suffix Assemblies are fitted with four gold plated copper spade connectors).
Maximum Head Temperature [4]:	80°C.
Lead Arrangement:	True potential 4-lead construction, designed to minimise thermal emf's.
Sheath Material:	Type 304 stainless steel.
Dimensions:	Length to Head: 241 mm (9.5") Head Length: 85 mm (3.35") Head Diameter: 19 mm (0.75") Sheath Diameter 8926: 3.6 mm (0.14") Sheath Diameter 8927: 4.8 mm (0.19")
Temperature Vs Resistance Tables:	Directions 177707, in 0.1°C steps.
Calibration:	Individual reports of calibration listing thermometer constants alpha (α), delta (δ) and resistance at the ice-point (R_0) from the CSIRO - National Measurement Laboratory (NML) are optionally available. Details provided on request.
Computer Compiled Calibration Data:	Tabular data provided in 0.1°C intervals (0.01°C resolution optionally available).

1. *Assumes maximum immersion of 180 mm.*

2. *To 100 ohm Platinum Resistance Thermometer Tables, Directions 177707. Conformity value improves by approximately ±0.1 ohm (±0.25°C) when "ice-point set" adjustment is used on 8078 Portable Precision Temperature Bridge.*

3. *Assumes a constant temperature stirred water bath with a water velocity of 1 m/s relative to the sensor.*

4. *Temperature of sheath where it enters head.*

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8926 and 8927 GENERAL PURPOSE PLATINUM RESISTANCE THERMOMETER ASSEMBLIES

1. INTRODUCTION

The 8926 and 8927 General Purpose Platinum Resistance Thermometer Assemblies have been designed to enable the accurate measurement of temperature in the range -200°C to +500°C. The temperature sensitive element is fabricated from high purity platinum wire which provides a definite and highly reproducible value of resistance as a function of temperature. By means of data (tables or constants) supplied with the thermometer, any reading of resistance obtained can be expressed in terms of the International Practical Temperature Scale of 1968.

2. DESCRIPTION

The sensing element is fabricated from high purity platinum wire which is fully annealed and essentially strain free. The element is mounted within a gas-tight type 304 stainless steel sheath, in a manner which provides good thermal transfer, protection against contamination, excellent stability and resistance to vibration. Careful cleaning and purging procedures ensure that all foreign substances are removed from the stainless steel tube, while a special passivation technique is used to impart a corrosion resistant film on the inside surface.

The design incorporates a true four lead (potential) type construction, whilst internal leads have been selected from materials which minimise thermal emf's. The use of high purity recrystallised alumina (Al_2O_3) insulation material limits the possibility of electrical leakage, particularly at high temperatures.

At the top of the stainless steel sheath assembly the leads pass through a seal which provides a gas-tight enclosure. This is fixed in position only after all traces of moisture are removed from components mounted within the assembly. The complete sleeve assembly is potted as a further safeguard against insulation leakage. As well as providing additional protection, the head can be used as a handle, particularly in field applications, to make the assembly more versatile. A flexible coil spring assembly, fitted to the head, protects the external cable from damage due to flexure.

A two metre flexible shielded lead is provided to which a 5-pin DIN plug is fixed. As an option (-"A" suffix) gold plated spade connections can be provided in lieu of the 5-pin DIN plug.

3. UNPACKING AND INSTALLING

Take the thermometer from its cardboard container and remove all protective wrapping. Although the 8926 and 8927 thermometers have been designed for laboratory, industrial and field applications, every care should be exercised at all times to minimise the chance of accidental damage or physical shock. Ideally, some permanent storage facility such as a rack or protected and lined drawer, should be made available for their safe keeping. The storage lid in the 003701 optional leather carrying case is ideal for this purpose.

Place the thermometer in the medium to be measured. For fixed applications such as a water or oil bath, the head can be clamped in a retort stand or similar arrangement, however in many applications the thermometer will be hand held, or special facilities developed to suit the requirement.

WARNING: If the thermometer is to be used to measure temperatures in excess of about 75°C, care should be exercised to ensure that the temperature of the stem, just below the head, does not exceed 80°C. This should not occur if the maximum recommended immersion of 180 mm (7") is not exceeded. In some instances it will be necessary to use a shield to minimise convective or radiated heat reaching the head.

4. MEASURING EQUIPMENT

The 8926 and 8927 General Purpose Resistance Thermometer Assemblies have been designed specifically for use with the 8078 Portable Precision Temperature Bridge. However, they can be used and will provide accurate and highly reproducible results with other three or preferably four lead measuring systems, such as the Leeds & Northrup 8067 Mueller Bridge, 8079 Extended Range Bridge, 8074 Resistance Thermometer Potentiometer Adaptor (with a suitable potentiometer), 8017-2 and 8064 series Portable Bridges and Numatron Digital Display Indicators. Where the 8078 Portable Precision Temperature Bridge is not used, the -"A" suffix should be specified, which provides five gold plated copper spade lugs in lieu of the 5-pin DIN plug.

The five thermometer leads, when provided, are identified as shown in Figure 1. The letters C and T designate potential connections, and the letters c and t designate current connections. Figure 2 shows the normal wiring arrangement when the 5-pin DIN plug is fitted.

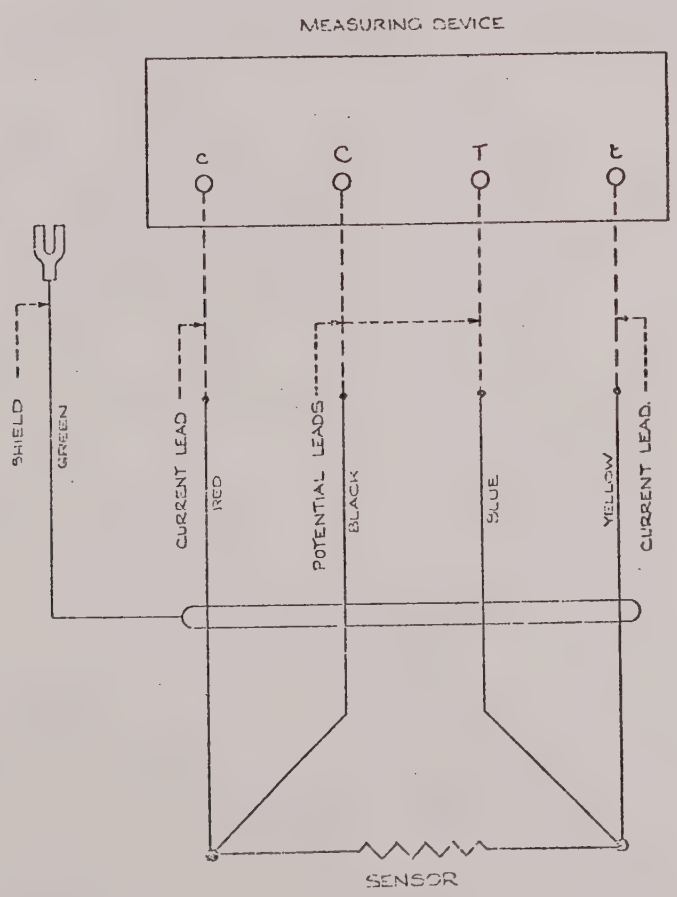

Figure 1 - Thermometer (Spade Terminal) wiring arrangement.

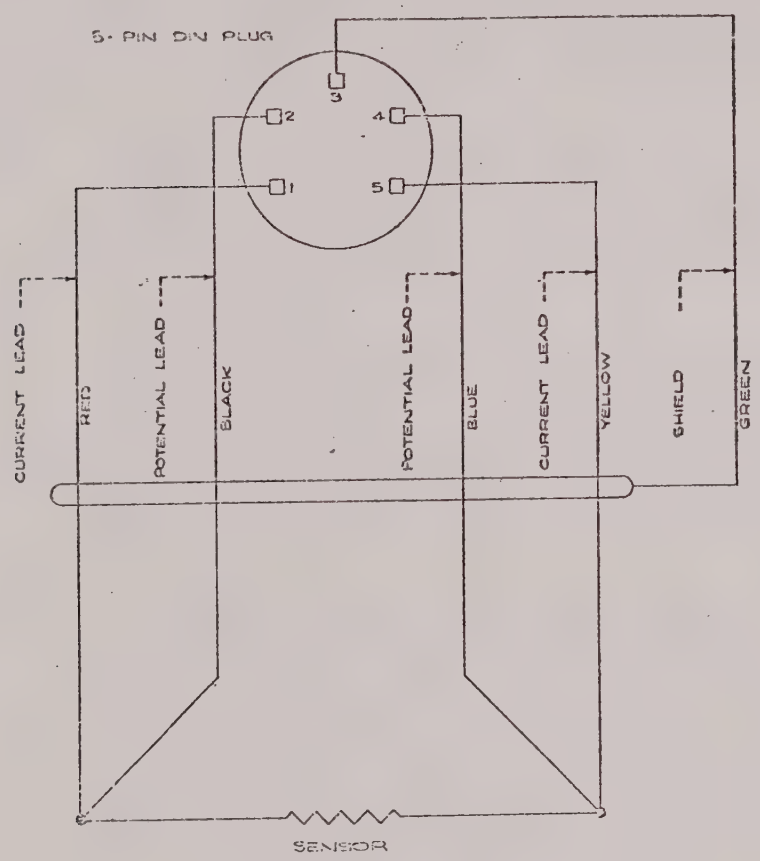

Figure 2 - Thermometer (DIN plug) wiring arrangement.

5. MAKING MEASUREMENTS

Connect the thermometer to the 8078 Portable Precision Temperature Bridge by plugging in the 5-pin DIN plug, or when using thermometers with the -"A" suffix, connect the five gold plated copper lugs to the measuring system terminals, noting the terminal identification in Figure 1.

In general, follow the procedure outlined in the directions of the equipment being used. When using the versatile 8078 Portable Precision Temperature Bridge, full operating instructions are provided in Directions 177703. However, irrespective of the equipment used, the following general precautions should always be observed:

(i) Before and after each use, carefully inspect the thermometer. Look for visible signs of damage such as a bent or damaged sheath, cut or cracked insulation on leads and, if fitted, a damaged 5-pin DIN plug.

(ii) The 8078 Portable Precision Temperature Bridge only passes 1 mA RMS current through the thermometer element; which results in minimum self heating and consequent errors. However, if the thermometer is used with other measuring systems, the current should be kept as low as possible, as calibration data (if supplied) may only be valid for low current values.

(iii) The self heating effect contributed by the 1 mA current from the 8078 Portable Precision Temperature Bridge will not normally affect readings taken, however in situations requiring maximum sensitivity, often where a recorder is used, sufficient time must be allowed for equilibrium to be established. When using equipment which passes greater current through the thermometer element, the effects of self heating should always be evaluated.

(iv) The thermometer must be immersed to a depth sufficient to prevent errors due to the transfer of heat along the thermometer sheath and internal leads. To obtain the best possible accuracy there should be no error introduced because of limited immersion. A check on the adequacy of immersion may be made by varying the depth of immersion of the thermometer and noting whether there is a change in resistance. The recommended minimum immersion depth for the 8926 and 8927 General Purpose Platinum Resistance Thermometer Assemblies, in a stirred water bath (assuming a uniform temperature zone and a water velocity of 1 m/s relative to the element) is 75 mm.

(v) When a d-c measuring device is used to make measurements it is important that the effects of emf's in the thermometer and the bridge measuring system be compensated.

6. CALIBRATION

It is not standard practice to provide individual reports specifying the resistance of each thermometer at $0^{o}C$ (R_0), or the constants alpha (α) and delta (δ). The thermometers are manufactured to very rigid standards and at the time of delivery are typically within the conformity limits stated on Page ii of these Directions. Standard tables, Directions 177707 entitled, "Temperature - Resistance Tables for 100 ohm Platinum Resistance Thermometers referenced to IPTS-68" are provided in $0.1^{o}C$ steps to aid interpolation of resistance readings to temperature.

WARNING: Even though the tables are listed in 0.1^{o} steps it does not imply that individual thermometers meet this accuracy index. Refer to conformity statement in specifications on Page ii for this information.

7. REPORT OF CALIBRATION

If an improved accuracy statement is required, over and above that guaranteed for a thermometer at the time of delivery, it may be possible to arrange such calibration through the CSIRO, National Measurement Laboratory. An NML Report of Calibration will include:

(i) The resistance of the thermometer at $0^{o}C$ (R_0)

(ii) Alpha (α) value.

(iii) Delta (δ) value.

NOTE: If requested L&N can supply an optional computer printout of temperature Vs resistance in $0.1^{o}C$ ($0.01^{o}C$ optional) steps for specified temperature spans, in the range -200 to $+500^{o}C$. Although a table may provide $0.01^{o}C$ steps, the thermometer stability and calibration accuracy are not necessarily of this quality.

8. INTERPRETING MEASURED RESISTANCE VALUES

The resistance readings obtained can be expressed in terms of the International Practical Temperature Scale of 1968 (IPTS-68) by the following means:

(i) Convert measured resistance to temperature using Directions 177707 entitled, "Temperature - Resistance Tables for 100 ohm Platinum Resistance Thermometers Referenced to IPTS-68". A detailed description of the procedure is included in Directions 177703.

(ii) Using a calibrated thermometer (7) where the thermometer R_0 value and constants are known, and calculate actual temperatures from measured resistance values using the formulas provided in the official text of the International Practical Temperature scale of 1968 (IPTS-68).

(iii) Using a calibrated thermometer (7) from which computer generated tables of temperature Vs resistance are provided. Such tables are usually tabulated in 0.1°C steps (0.01°C optional) and will provide a high degree of accuracy. They can be extrapolated for difference measurements to a resolution of 0.001°C without error. The tables will be generated (unless specially requested otherwise) with a resistance at 0°C (R_0) value of 100.000 ohm instead of the measured value provided in the NML report of calibration. This implies that the "ICE POINT SET" setter on the 8078 Portable Precision Temperature Bridge must be used to obtain correct measured values. For highest precision a freshly prepared ice point reference (refer to APPENDIX A "ESTABLISHING AN ICE POINT REFERENCE" in Directions 177703) should be used to determine the correct thermometer resistance at 0°C (R_0) value; however for routine measurements the last recorded resistance at 0°C (R_0) value for a specific thermometer can be set on the "ICE POINT SET" setter. This procedure has the distinct advantage of continually checking and if necessary updating the thermometer resistance at 0°C (R_0) value; hence negating the preparation of a further set of tables should this value change.

NOTE: The frequency that actual ice point checks should be made will depend on many parameters, including the precision required, the time span between measurements, the temperature span through which the thermometer has been cycled and the stability characteristics of the actual thermometer itself. Hence the user will have to evaluate all parameters before making a decision, however where highest precision is required it is considered good practice to make an ice point check prior to and at the conclusion of each set of measurements.

Method (i) is the simplest procedure, but is the least accurate as no correction is made for the nominal ice point value* of a particular thermometer and additionally assumes a nominal α and δ value. Methods (ii) and (iii) overcome these limitations and will provide the best possible result.

Directions 177703 entitled, "8078 Portable Precision Temperature Bridge, Operator's and Service Manual", provides a more detailed description of the various methods of determining temperature from measured resistance values.

* *Special provision is included, via the ice point set facilities on the*

8078 Portable Precision Temperature Bridge to correct for the nominal ice point value of particular thermometers. If this is used the tolerances in the tables on page (ii) are substantially reduced (typically 0.1 ohm), even when the other thermometer constants are not known.

9. PERFORMANCE CHARACTERISTICS

The stability and repeatability of platinum resistance thermometers to a large extent depends on the environment in which they are used. It is, therefore, difficult to provide realistic values for the 8926 and 8927 General Purpose Platinum Resistance Thermometer Assemblies; however in the range 0 to 100°C, possibly the most used span, a repeatability of 0.002 ohm (0.005°C) or better, is typical.

Extending the range, either downward or uwpard, toward maximum limits, will reduce the reproducibility and stability of all thermometers. Hence to achieve the best results over the widest temperature span it is preferable to use a number of thermometers (typically three) and allocate each thermometer for use in a specified temperature band. The following table 1 suggests a practical arrangement.

THERMOMETER	SUGGESTED OPERATING RANGE
Number 1	0 to 100°C
Number 2	Above 100°C
Number 3	Below 0°C

Table 1. Suggested Thermometer Operating Range.

WARNING: *Each 8926 or 8927 General Purpose Platinum Resistance Thermometer outer sheath is manufactured from corrosion resisting type 304 stainless steel and, therefore, can be used in most environments within the stated operating temperature range. However, because of the very fine conductors and high purity insulation material used in construction, and the overall small diameter of the design, care should be exercised to ensure that the outer thermometer stem is not bent, distorted or flattened.*

10. REPAIRS

Because of their sealed nature, thermometers which lose continuity or are damaged, are extremely difficult to repair. Repair can only be effected at the factory of manufacture, i.e. Leeds & Northrup Australia Pty. Limited, 298 Botany Road, Alexandria, New South Wales 2015, Australia. Prior to return, an evaluation of the problem should be made by a Leeds & Northrup representative to determine if such repair is feasible and/or economical.

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